REMARKS

Applicants acknowledge the indication of the allowability of the subject matter of Claims 6 and 8 as set forth on page 3 of the Office Action. In particular, the latter claims would be allowable if rewritten in independent form. By the foregoing amendment, that has been done, and Claims 6 and 8 as amended are therefore believed to be allowable. Moreover, for the reasons set forth hereinafter, Applicants respectfully submit that remaining independent Claims 1 and 10, and therefore all remaining claims in this application are now allowable as well.

The present invention is directed to a method and apparatus for reducing the noise of turbo engines, which include a sequential arrangement of rotating and stationary blade cascades, sometimes referred to as rotors and stators.

One of the primary sources of noise in such engines is attributable to interaction between the rotating unstationary blades. That is, due to the periodic peripheral wave of a rotating blade cascade, a downstream stationary blade cascade is exposed to periodic transient flow, which causes periodic hydrodynamic pressure fluctuations to be applied to the stator blades. A similar interaction takes place when blades of a rotating blade cascade penetrate the stationary wave coming upstream stationary blade cascade. In both cases the impingement of the periodic pressure fluctuations on the blades themselves

stimulates the emission of tonal noise to the surrounding area, as discussed, for example, in paragraph [0005] of the specification.

The present invention addresses and resolves this problem by lowering the hydrodynamic pressure fluctuations which occur on the blade cascades through variation of the surface circulation of at least one section of at least one stator. Thus, unlike known active noise suppression techniques, the method and apparatus according to the present invention directly address the source where the noise is produced. In particular, the actuators used in the method according to the invention to vary the surface circulation on at least one section of the stator do not serve to generate an "antinoise" field, which compensates the sound field produced by the turbine engine. Rather, by reducing the hydrodynamic pressure fluctuation which impinge on the rotor and stator blades, the present invention reduces the level of noise generated in the first place, rather than cancelling it out after it is generated.

For this purpose, in the method and apparatus according to the invention, an aerodynamic characteristic of at least one section of at least one stationary blade cascade is varied at a frequency that corresponds to the product of a number of rotor blades of one of the rotating blade cascades and a rotational speed thereof, so that the surface circulation on the at least one section of the stationary blade cascade varies in a manner that corresponds to the periodic

variation. In this manner, as noted previously, hydrodynamic pressure fluctuations that impinge on the cascades are reduced, thereby inhibiting the generation of noise due to the interaction of such fluctuations of the blades of the rotating and stationary blade cascades. In particular, as noted in paragraph [0015], the control frequency of the periodic processes advantageously corresponds to the base frequency of the tonal noise, and is obtained from the product of the number of rotor blades and the rotational speed, as recited, for example, in allowable Claim 8. Independent Claims 1 and 10 have been amended to also recite this feature of the invention. (See specification at paragraphs [0014]; [0015], lines 1-11; and [0025], lines 5-9.) Applicants respectfully submit that none of the cited prior art references teaches or suggests the method of Claim 1 or the apparatus of Claim 10, in which the aerodynamic characteristics of a section of one of the stationary blade cascades is controlled at a frequency that corresponds to the product of a number of rotor blades of one of the rotating blade cascades in rotational speed thereof, so that the surface circulation on the at least one section of the stationary blade cascade varies in a manner that corresponds to the periodic variation.

The Schlinker et al patent, for example, differs from the present invention, in that it relies on noise attenuation (as opposed to prevention) by generating "antisound" pressure waves have a "a phase and amplitude size to cancel the acoustic pressure wave generated by the interaction between the fluctuation and

the air foil leading edge". (See, for example, Column 1, lines 36-41 and 47-50; Column 2, lines 36-43 and Column 3, lines 34-39.) Thus, as noted at Column 2, lines 37-39, Schlinker et al provides a system and technique for generating "antisound" which is of a proper magnitude and phase, so as to "cancel a substantial portion of the acoustic noise generated" by the vane-wake interaction.

For the latter purpose, Schlinker et al provides several different embodiments, illustrated in Figures 3-5, which include, for example, a piston 30, which oscillates transversely with respect to a vane 10 (Figure 3); a movable portion 10a at the leading edge 18 of a vane 10 (Figure 4), and a resonance chamber arrangement (Figure 5). While the above structures parallel those of the present application, for the reasons noted above, the control of such apparatus, and the mechanism by which sound is reduced is fundamentally different. In particular, each of the cited embodiments is controlled in such a manner as to attenuate noise in the form of sound waves, which are in fact generated by the interaction of the pressure waves on the rotor or stator vanes, rather than by the method according to the present invention, as defined in Claims 1, 8 and 10 which reduces the pressure that impinges on the vanes so as to prevent the generation of noise in the first place. Accordingly, Applicants respectfully submit that all claims of record in this application distinguish over the Schlinker et al patent.

The Hoch et al patent, on the other hand, uses an inflatable blade arrangement to vary the cross-section of the intake flow path of a turbine engine, and create a "sonic throat" or restriction, which causes a "sonic flow" (mach 1.0). This arrangement has the effect of attenuating the noise component that propagates upstream through the air intake of the turbine engine. (See, for example, page 1, lines 23-25 and 57-81; page 3, lines 6-28.)

As a result of the manner in which it operates, the Hoch et al patent makes no provision for periodically varying the aerodynamic characteristics of the blades in a manner which corresponds to that of independent Claims 1 and 10, as well as independent Claim 8. Moreover, given the purpose for which the blades are inflated, being to create a "sonic throat" there would be no utility in doing so. Indeed, such an arrangement would appear to interfere with the manner of operation of the Hoch et al apparatus.

The Ho et al patent, on the other hand, uses cross-flow channels 54 (Figures 4 and 5) in order to reduce the differential static pressure at opposite sides of struts 36 (or outlet guide vanes 38). (See Column 3, line 53 - Column 4, line 34, and especially Column 4, lines 12-19.) Thus, Ho et al provides a purely passive noise reduction technique, which makes no provision for periodically varying aerodynamic characteristics of the blade cascades, at a frequency that

corresponds to the product of a number of rotor blades of one of the rotating blades cascades in a rotational speed thereof.

Finally, the Dunbar et al patent discloses a method of noise reduction in which the pitch of the vanes is adjusted to "a preselected value" as a function of current fan rotor speed during a noise reduction mode, and adjusted to a "preestablished value" as a function of the current fan rotor speed measurement during a cruising mode. (See, for example, Column 2, lines 8-17.) Thus, as noted at Column 4, line 66 through Column 5, line 3, "the value of the pitch of the vanes 52, which minimizes engine noise for a noise reduction mode of engine operation is a function of the fan rotor speed and can be preselected by analytical calculations or by empirical measurements. . . ." For a particular rotor speed, therefore, the pitch is adjusted to a corresponding value, and no provision is made for periodically varying it in the manner disclosed and claimed in the present application.

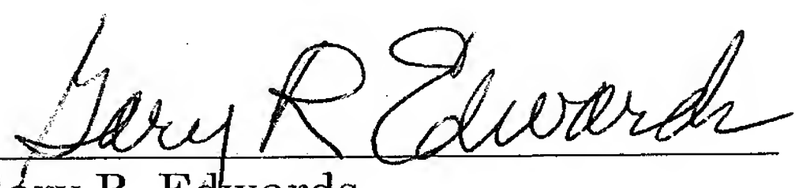
Accordingly, for the reasons set forth above, Applicants respectfully submit that all claims of record in this application distinguish over the cited prior art references, and are allowable.

In light of the foregoing remarks, this application should be in condition for allowance, and early passage of this case to issue is respectfully requested. If there are any questions regarding this amendment or the application in general,

a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323, Docket No. 056226.57694US.

Respectfully submitted,



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